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PUMPSKID FOR SUCTION ANCHORS

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PUMPSKID FOR SUCTION ANCHORS

TECHNICAL FIELD

This invention relates to a pumpskid useful in conjunction with a remotely operated vehicle for installing and removing suction anchors in deep water installations.

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BACKGROUND AND SUMMARY OF THE INVENTION

U.S. Patent No. 4,318,641 granted to Hogervorst on March 9, 1982, and assigned to Shell Oil Company discloses a suction anchor. Briefly, a suction anchor comprises a length of steel tubing having a relatively large diameter and a relatively long length, for example, a typical suction anchor might be 12 feet in diameter and 60 feet in length. The suction anchor has an open bottom and a top equipped with structure which allows water to be pumped out of the interior of the suction anchor thereby establishing a pressure differential which causes the suction anchor to penetrate the seafloor. The suction anchor is adapted for subsequent removal from the seafloor by pumping water into the interior thereof.

The Hogervorst '641 Patent discloses in FIGURES 1 and 2 a first pumping apparatus and in FIGURE 7 a second apparatus which may be used to effect the flow of water out of or into a suction anchor. Although mentioning structure for clamping the pumping apparatus to the suction anchor, the details of the clamping apparatus are not further disclosed. It is not at all clear from the specification of the Hogervorst '641 Patent that the pumping apparatus described therein can be actuated to effect rapid reversal of the direction of water flow relative to the suction anchor which may be necessary to free the suction anchor from the seafloor in the event that the material into which

the suction anchor has been installed has become consolidated around the interior and exterior walls thereof. Also, the apparatus disclosed in FIGURE 7 of the Hogervorst '641 Patent for guiding the pumping apparatus downwardly from the surface and into engagement with the suction anchor is not considered adequate for use in deep water installations.

The present invention comprises a pumpskid useful in conjunction with a remotely operated vehicle for installing suction anchors in deep water installations. In accordance with the broader aspects of the invention, the pumpskid is provided with structure for securely clamping the pumpskid in engagement with the suction port of the suction anchor. The pumpskid is provided with remotely operable valving apparatus for causing a pump mounted on the pumpskid to pump water either out of or into the suction anchor as may be required. The valving apparatus may be operated to rapidly reverse the direction of water flow relative to the anchor thereby dislodging a suction anchor which may have become too firmly imbedded in the seafloor.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to FIGURES 1 through 5, therein is shown a steel suction anchor 70 useful in the practice of the invention. The suction anchor 70 is a right circular cylinder 12 feet in diameter and 60 feet in length, having a wall thickness of 1.5 inches. Skids 71, which may comprise lengths of angle iron or lengths of pipe cut in half longitudinally, are welded to the cylinder comprising the anchor 70 to prevent it from rolling on the deck of an installation vessel.

The suction anchor 70 is open on the lower end 72 and closed at the upper end 74 by a plate 76. A padeye 78, for receiving a mooring line, is attached on an exterior side of suction anchor 70 approximately 40 feet from the top. The top closure plate 76 on the upper end 74 of suction anchor 70 includes ports 82 which allow water to flow through the closure plate 76 as the anchor 70 heaves up and down during lowering to and retrieval from the seafloor. The ports 82 are opened and closed by worm gear actuators 83 which are in turn operated by a manipulator extending from a remote operation vehicle (ROV) 300 which is located relative to the ~~skid 80~~ suction anchor 70 by docking posts 84. ROV 300 may comprise a Raycal SEA LION Mk.II heavy work class ROV having 100 horsepower; however any of the various commercially available ROV's having 75 h.p. or more can be used in the practice of the invention.

Vertical alignment of the anchor 70 is determined using a camera on the ROV 300 which observes a bullseye level 85. The ROV 300 also adjusts the horizontal alignment of the suction anchor 70 by checking the suction anchor's heading with a gyrocompass onboard the ROV. If the horizontal alignment is out of tolerance, the ROV 300 rotates the suction anchor 70 by activating thrusters on the ROV. The placement of the ROV 300 on the outer edge of the closure plate 76 ensures that the ROV's thrusters can apply adequate torque to rotate the suction anchor 70 about its axis.

Padeyes 86 are used to connect the anchor to a recovery bridle. An alternate padeye 87 may be used with a single recovery pendant or with double recovery sling. A suction port 88 having a clamp down hub is engaged by the ROV 300 to effect pumping of water into or out of the anchor 70.

A pumpskid 160 comprising the present invention is shown in FIGURES 6, 7, 8, and 9. The ROV 300 is fitted with the pumpskid 160 which is mounted beneath the ROV. The pumpskid 160 includes a centrifugal pump 162, a hydraulic motor 163 which drives the pump 162, pump manifold valve actuators 164 and 165, and latching actuators 166, all powered and controlled by the hydraulic system of the ROV 300. The pumpskid further includes a male connector 168 for the suction port 88. The male

connector is provided with O-ring seals 169 to ensure a water-tight connection with the suction port 88. Valves 170 and 172 are operated by actuator 164 and valves 174 and 176 are operated by actuator 165.

As is shown in FIGURES 8, 9, and 10, the ROV 300 docks and latches onto the suction anchor 70 and its suction port 88 by engagement of the male connector 168 and by actuating the latching actuators 166. The latching actuators 166 comprise hydraulic cylinders which are actuated from the ROV 300. Each latching actuator 166 has a piston rod 178 extending therefrom. The distal end of each piston rod 178 comprises a truncated cone 180. The suction port 88 of the suction anchor 70 has a clamp down ring 182 which is provided with a tapered circumferential slot 184 adapted for mating engagement with the cones 180 to securely clamp the pumpskid 160 and the ROV 300 in engagement with the suction anchor 70.

After the latching actuators have been operated to engage the cones 180 with the tapered slot 184 to secure the pumpskid 160 to the anchor 70, the ROV closes the ports 82. The pump 162 of the pumpskid 160 is started and pumps water out of the interior of the suction anchor 70, reducing the water pressure inside relative to the outside pressure. This is accomplished by means of actuator 164 which opens valve 170 and closes valve 172 and actuator 165 which opens valve 174 and closes valve 176, thereby causing

water to flow through suction port 88, valve 174, pump 162, and valve 170, and then out through a port 188 which is open to the surrounding sea. As will be understood, the mechanical linkage 190 extending between the actuator 164, the valve 170, and the valve 172 assures that whenever valve 170 is open valve 172 is closed, and vice versa. Likewise, the linkage 192 between actuator 164, valve 174, and valve 176 assures that whenever valve 174 is open valve 176 is closed and vice versa.

The differential pressure under the action of pump 162 acts as a downward force on the top of the suction anchor 70 pushing the suction anchor further into the seafloor to the desired penetration depth. When the desired penetration has been reached, as determined from a depth monitoring system on the ROV 300, the ROV disconnects from the top of the suction anchor 70. This is accomplished by operation of the latching actuators to withdraw the cones 180 from the tapered slot 184. Next the ROV checks the suction anchor penetration by reading the penetration marks at the mudline. When the suction anchor 70 penetration is found to be within tolerance, the ROV 300 closes the suction port 88 so that all openings in the top of the suction anchor are closed. The ROV 300 then disconnects the lowering line from the recovery buoy 146 and is retrieved to the surface.

Whenever removal of the suction anchor 70 is desired,

the ROV 300 docks onto the suction anchor top and latches onto the suction port 88.. This is accomplished by operating latching actuators 166 to force the cones 180 into the tapered slot 184. As is shown in FIGURE 11, the ROV 300 pumps water into the interior of the suction anchor by means of the pump 162. This is accomplished by operating the actuators 164 and 165 to open valve 176, open valve 172, close valve 174, and close valve 170, thereby causing water to flow through port 188, valve 172, pump 162, valve 176 and port 88 into anchor 70.

Due to the pump 162, the water pressure inside becomes greater than the outside water pressure, and the differential pressure results in an upwards force on the suction anchor top. The upwards force, and the pull on the recovery line pulls the suction anchor out of the seafloor. If too much pump pressure is required to pull the suction anchor 70 out of the seafloor, due to too much consolidation of the soil around and inside the suction anchor, the water flow direction from the pump 162 can be reversed instantaneously by changing the positions of valve actuators 164 and 165. By rapidly changing the water flow direction from pumping in to pumping out, the suction anchor 70 will be alternately pulled out and pushed in. When this is done for some time, the soil in contact with the suction anchor cylinder will liquefy, making it easier to pump and pull the suction anchor out off the soil.

Suction anchor 70 is raised to the surface by a recovery line and is loaded on an installation vessel using the riser line 50.

The pumpskid 160 is provided with a differential pressure gauge 194 which is connected to the male connector 168 by a pressure line 196. The pressure line 194 indicates the difference in the pressure of the water within the connector 168 with respect to the pressure of the water outside of the suction anchor. The ROV 300 monitors the gauge 194 during suction anchor installation and removal operations to assure that the differential pressure between the inside and the outside of the suction anchor remains within predetermined limits.

The water pumping rate can be adjusted from the ROV 300 by controlling the rate of flow of pressurized hydraulic fluid to the hydraulic motor 163. Reduction in the water flow rate may be required if either the suction anchor penetration rate, or the suction anchor withdrawal rate, or the differential pressure between the interior and the exterior of the suction anchor is too high.

The pumpskid 160 is fitted with syntactic foam buoyancy elements 196 designed for the maximum operating water depth. The buoyancy elements 196 ensure that the pumpskid 160 is slightly buoyant when submerged.

Although preferred and alternative embodiments of the invention have been illustrated in the accompanying

Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements and substitutions of parts and elements without departing from the spirit of the invention.